Chapter 6

TECHNOLOGY

Part A: Technology Education

Part B: Educational Technology

Science and *technology* are commonly linked in our popular culture, including the mainstream media. Since the word technology is often misunderstood, a clarification of the relationship between science and technology is needed, as well as a description of the role of technology in education. The first section of this chapter is devoted to a discussion of the broad study of technology and its relationship with science. The second section of this chapter will identify the role of computers and other devices (*educational technology*) as they are used to enhance classroom instruction.

PART A: TECHNOLOGY EDUCATION

SCIENCE AND TECHNOLOGY

The essential link between science and technology is clearly established in the *New Jersey Science Standards* as well as other national and state reform movements such as Project 2061 and the *National Science Education Standards*. These initiatives recognize technology education as a necessary component of science education. Indeed, one of New Jersey's most recent major reform efforts, the *Statewide Systemic Initiative (SSI)*, is dedicated to achieving excellence in mathematics, science, and technology education. In *Benchmarks for Scientific Literacy*, a publication of Project 2061 and an important resource used in the preparation of the science content standards and this *Framework*, it was concluded that if scientific literacy is to be achieved, the "nature of technology" and the "designed world" must be essential components.

Understanding the symbiotic relationship between science and technology is key to gaining scientific literacy. By studying science and technology, students gain a unique perspective on these important forms of human thinking and doing. Science seeks answers to questions about the natural universe and answers the question "Why?" Technology, in attempting to adapt our environment, seeks answers to questions about the designed world and answers the question "How?" Advances in scientific knowledge often support new technological inventions as the human need to learn more about the natural universe presents new problems for technological development. To quote from Project 2061,

> In the broadest sense, technology extends our abilities to change the world: to cut, shape, or put together materials; to move things from one place to another; to reach further with our hands, voice, and senses. We use technology to try to change the world to suit us better. . . . But the results of changing the world are often complicated and unpredictable. They can include unexpected benefits, unexpected costs, and unexpected risk.

Teaching New Jersey's students to appreciate those costs, benefits, and risks is one of the intentions of the *Science Standards*.

TECHNOLOGY AS PROCESS, KNOWLEDGE, AND ARTIFACT

Technology can be thought of as process (design), as knowledge (learned principles), and as artifact (products, tools, and instruments).

Technological design is the planned process of change. Designing demands that we plan change so that we end up with desired results, minimize trade-offs, and control risk. Technologists, such as engineers, industrial designers, and architects, use the process to find solutions to technological problems.

The *learned principles* we use to solve these problems—including the information, theories, and organizational and technical processes—are also part of technology. When Thomas Edison invented the light bulb and electrified communities and when Henry Ford created a new organization around mass-production principles, much more than new products and systems were produced. Also impacted were the nature of work, where people lived, and how society moved people and products.

Since things that we can see and touch are typically the solutions to the problems we want to solve, it is easy to see how *artifacts* can be considered technology. Since the early Science/Technology/Society initiatives, the value of having students understanding devices (i.e., learning to use them, understanding how they work, and feeling comfortable with contemporary products of technology) has been recognized. Students should understand and be capable of using the computer and the microscope as well as their VCR. The use of these artifacts should be associated with the learning of scientific or mathematical principles or the solving of technological problems.

TECHNOLOGY AND THE SCIENCE STANDARDS

Consistent with the call by the National Science Foundation (1992) and the American Association for the Advancement of Science (1993) for scientific literacy and the integration of mathematics, science, and technology education is the identification of technology-related standards by the New Jersey State Department of Education. Most technology standards are found listed in the *New Jersey Core Curriculum Content Standards* under the science and cross-content workplace readiness sections. Indeed, *Standard 5.4* (referred to in this *Framework as Science Standard 4*) calls for all students to develop an understanding of technology as an application of scientific principles. An excellent source of information about specific standards for technology programs can be found in *A Framework for the Study of Technology in New Jersey* (TEANJ, 1996) in the chapter entitled "Standards for Technology Programs."

The AAAS panel report on technology prepared in conjunction with Project 2061 includes a section entitled "Aspects of Technology Education" and devotes a larger section to identifying those technologies thought by the panel to be "important for a graduating senior to know." Cross-referencing this list with New Jersey's *Science Standards* presents the *Framework* user with frequent and obvious opportunities to fuse technology education with standards-based science instruction.

For example, the report states that technology education should emphasize problem solving, observation, measurement, analysis, and communication skills (*Science Standard 2* and *Cross-Content Workplace Readiness Standard 3*). Students should learn to question basic assumptions *(Science Standard 2)* and to recognize the components of systems *(Science Standard 1)*. Learning about technology should include historical examples *(Science Standard 3)* as well as contemporary illustrations. The report also focuses on the inescapable connections between mathematics, science, and technology *(Science Standards 4 and 5)*.

When we look at the important technologies identified by the panel, we see the close relationship between those science standards that address fundamental understandings in life, Earth, physical, and environmental sciences, and the objectives of technology education. For example:

- Materials technology calls for an understanding of the structure of matter, physical and chemical properties, and the conditions that affect materials *(Science Standards 8 and 9)*.

- The report states that "the principles of energy and its use should be taught in science courses, but their application must be thoroughly demonstrated in technology activities in elementary and secondary school." Those principles appear throughout the *Science Standards (1, 2, 4, 9, and 12)*.

- Understanding the technology of agriculture, food production, and food distribution involves the chemistry of fertilizers, herbicides, additives, etc., as well as fundamental principles of botany *(Science Standards 6, 7, and 8)*.

- Biotechnology and medical technology, our oldest and (in a way) most personal technologies, may present us with controversial choices that demand a thorough understanding of the underlying science of living things and, in particular, human anatomy *(Science Standards 2, 6, and 7)*.

- Understanding and protecting the environment (including the atmosphere) requires some knowledge of virtually every field of science—the life sciences, Earth science, and chemistry—and the ability to correctly interpret data and make informed decisions *(Science Standards 1, 2, 4, 5, 6, 8, and 12)*.

- The panel suggests that communications and information technology should be looked at from a historical perspective, tracing the evolution of communications devices and the physics that explain them—from electrons to waves to digital telecommunications and beyond *(Science Standards 1, 3, 4, 8, and 9)*.

- Transportation technology—using land, water, air, or outer space—requires some knowledge of each of these mediums as well as an understanding of systems, energy, forces, and motion *(Science Standards 1, 4, 5, 9, 10, 11, and 12)*.

SOCIAL IMPACTS

Technology: Curse or Answer? People throughout history have wanted to stop change. The Luddites of eighteenth-century England (named after their leader, Ned Lud) wanted to halt technological progress by smashing the new weaving machines being introduced into the textile industry of the time. Fabric had been produced by a decentralized cottage industry, but the new machines were eliminating jobs and changing the work of those that remained. The effect of the Luddites was minimal, and the weaving machines helped bring about the Industrial Revolution in Britain.

At the other extreme are those individuals who believe that any problem can be corrected through technological innovation. This techno-fix mentality seems to negate the need for careful consideration of issues and balance human responsibility concerning the impact of technology on the individual, society, and the environment. This position also ignores the evidence that solving one problem inevitably leads to another problem.

As we face the choices presented by technology, we must remember to weigh these issues against the impact on the individual, society, and the natural environment. Products should be carefully designed; consumers must carefully choose; and citizens, through governmental regulations, must balance the trade-offs and risks of future technological progress for the betterment of all people.